J Parasit Dis (Oct-Dec 2015) 39(4):604–612
DOI 10.1007/s12639-013-0402-6

REVIEW ARTICLE

Larva migrans in India: veterinary and public health perspectives

Rajnish Sharma · B. B. Singh · J. P. S. Gill

Received: 22 July 2013 / Accepted: 9 November 2013 / Published online: 3 December 2013

Abstract Despite an important public health problem in developing world like India, larva migrans remains a neglected zoonosis. Cutaneous larva migrans, Visceral larva migrans, and Ocular larva migrans are the important clinical manifestations seen in humans in India. Although many nematode parasites have the ability to cause the infection, the disease primarily occurs due to *Ancylostoma caninum* and *Toxocara canis*. Presence of the infection in dogs is an indirect indication of its incidence in humans in endemic regions. In India, sporadic cases of this neglected but important parasitic zoonosis are the main implications of lack of diagnostic methods and under-reporting of human cases. Tropical climate in addition to overcrowding, poor hygiene and sanitation problems, stray dogs, open defecation by dogs and improper faecal disposal are the important factors for persistence of this disease in the country. Sanitary and hygienic measures, improved diagnostic techniques and surveillance programme in dogs as well as humans should be adopted for its effective control. Comprehensive collaborative efforts by physicians and veterinarians are required to tackle this problem in order to attain optimal health for humans, animals and the environment. Moreover, recognition of larva migrans as an important public health problem is the most important step to combat this neglected disease in developing countries like India.

Keywords India · Larva migrans · Public health · Zoonosis

R. Sharma (✉) · B. B. Singh · J. P. S. Gill
School of Public Health and Zoonoses, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana 141004, Punjab, India
e-mail: rajgangahar@gmail.com

Introduction

Zoonotic parasites are important from veterinary, public health and economic point of view in India and many other developing nations (Singh et al. 2010, 2011, 2012, 2013). Larva migrans is a parasitic zoonosis that is caused by migration of parasitic larvae in different parts of the body. Numerous animal parasitic larvae are responsible for larva migrans in humans (Chaudhry and Longworth 1989; Bryceson and Hay 1992; Nawa et al. 1996; Brasil et al. 2006; Kurokawa et al. 1998; Vega-Lopez and Hay 2004; Tamminga et al. 2009). Depending upon the involvement of body parts, larva migrans can be classified into four categories viz. Cutaneous larva migrans (CLM), Visceral larva migrans (VLM), Ocular larva migrans (OLM) and Neural larva migrans (NLM). These parasites are important not only from a veterinary stand-point but also a public health perspective, as they are potentially zoonotic (Chaudhry and Longworth 1989; Traub et al. 2004, 2007). CLM has been commonly reported from tropical and subtropical geographic areas; however, due to increased international travel, it is no longer confined to these areas (Shinkar et al. 2005). Resultantly, CLM is the most frequent skin disease among travelers returning from tropical countries (Caumes 2000; Bouchaud et al. 2001). Although widely distributed, VLM is most commonly seen in the tropical and developing countries, where the sanitary and hygienic conditions are poor (Tao et al. 2012).The parasitic larvae when invade the eye may lead to OLM. NLM is invasion of the brain and/or spinal cord by parasitic larvae (Kazacos 2001). High prevalence of ancylostomosis and toxocarosis has been observed in different parts of India. However, data are scanty on larva migrans in humans. In the present review, an update on veterinary and public health perspectives of larva migrans in India has been provided.

Cutaneous larva migrans (CLM)

History

Initial published report of CLM was credited to Lee, an English physician (Nash 1990). The term "Cutaneous larva migrans" was coined by Crocker (1893). Hammelstjerna proved that CLM had parasitic etiology in 1896.

Etiology

Various synonyms such as creeping eruption, plumber's itch, sand worm, duck hunters itch and epidermatitis linearis migrans are used to describe CLM (Neafie and Meyers 2000). CLM is caused by the larvae of animal hookworms, especially those of dogs and cats viz *Ancylostoma caninum* and *A. braziliense* (Chaudhry and Longworth 1989; Beaver 1956). Other nematodes associated with the disease include *Uncinaria stenocephala, Bunostomum phlebotomum*, *Gnathostoma spinigerum*, *Dirofilaria* sp. and *Strongyloides westeri* (Bryceson and Hay 1992; Kurokawa et al. 1998; Vega-Lopez and Hay R 2004; Tamminga et al. 2009). Filariform (third-stage, L-3) larvae are infective stage and penetrate the skin of the host (dog and man). In dogs, L-3 stage develops into adult but no such development occurs in man (CDC 2013).

Epidemiology

The disease is worldwide in distribution and has been reported from Africa, South and Central America, Southern USA, South–East Asia, Southern France, Spain and Australia (Manson-Bahr and Bell 1987). Factors such as tropical climate, overcrowding, poor hygiene and sanitation problems contribute to the causation (Meffert 1977). Among travelers returning from tropical countries, CLM is the most frequent skin disease (Caumes et al. 1995; Bouchaud et al. 2001). India has a huge population of $\sim$19.2 million stray dogs. Stray dogs play a major role in the environmental contamination with the helminth eggs. In India, presence of stray dogs, open defecation by both stray and pet dogs, improper faecal disposal are the conducive factors for the persistence of *Ancylostoma* and *Toxocara* eggs in the environment. CLM patients usually have a history of visiting public places (beaches or bus stops etc.) commonly accessed by stray dogs (Sugathan 2002; Kartikeyan et al. 2003; Mehta and Shenoi 2004; Gutte and Khopkar 2011). CLM appears to be common in low socioeconomic communities. Walking bare foot on or sleeping/working in contaminated soil are other important factors responsible for CLM in humans (Padmavathy and Rao 2005; Malhotra et al. 2006; Rao and Prabhu 2007; Mohanty et al. 2012).

Status in India

Occurrence in humans

In India, sporadic cases of CLM have been reported and are summarized in Table 1. The high prevalence of *A. caninum* and *A. braziliense* in dogs in tea growing community could account for the incidence of CLM observed among the human population residing at the tea estates, Assam (Traub et al. 2004). Inspite of high prevalence of ancylostomosis in dogs in India (Traub et al. 2002; Agnihotri et al. 2008; Das et al. 2009), data on epidemiology of CLM in humans is largely missing possibly due to under reporting and misdiagnosis of the disease (Sugathan 2002).

Occurrence in dogs

Both the hookworm species *A. caninum* and *A. braziliense* are endemic in dogs in India (Traub et al. 2004, 2007). The prevalence of infection ranges from 19 to 94 % in different parts of the country (Traub et al. 2002; Agnihotri et al. 2008). Infection rates were 50.5, 71 and 73 % in Miraj, Uttar Pradesh and Bangalore, respectively (Malaki 1966; Sahai 1969; Joshi and Sabne 1977). Khante et al. (2009) reported 20 and 25 % infection rate among adult and young stray dogs in Nagpur. In Himachal Pradesh, 19.06 % incidence was recorded during the coprological examination of 236 dogs (Agnihotri et al. 2008). Prevalence reported was very high (94 %) in dogs in three tea estates in Assam and was maximum among the other GI parasites observed (Traub et al. 2002). 72 % of dogs were found to harbour *A. caninum*, 60 % harboured *A. braziliense* and 37 % harboured mixed infections with both hookworms (Traub et al. 2003). Das et al. (2009) reported 51.53 and 19.73 % prevalence rates of *Ancylostoma* spp in stray and pet dogs, respectively in Puducherry. Most of the earlier studies were based on coprological examination, thus did not distinguish *Ancylostoma* species or might have wrongly interpreted the results (Malaki 1966; Sahai 1969; Joshi and Sabne 1977). Molecular studies should be performed to know the exact status of the hookworm species *A. caninum* and *A. braziliense* in various parts of the country as these techniques are must for species differentiation (Traub et al. 2003).

Health implications in humans

The clinical features of CLM vary from non-specific dermatitis to typical creeping eruption (Karthikeyan and Thappa 2002). An erythematous itchy papule is observed as first lesion followed by about 2–3 mm thick, raised pink or flesh colored swollen lesion. Later on, there is formation of linear, serpentine (serpiginous) or bizarre tracks

Table 1 Cases of CLM in humans in India

S. No	Age (years)	Sex	Occupation	Site	History/risk factor involved	Reference
1	45	M	Massage therapist	Arms, face, whole back	Slept on a wet bus station floor	Sugathan (2002)
2	24	M	Agricultural labourer	Penis	Visited a beach resort	Kartikeyan et al. (2003)
3	26	M	Fisherman	Back and arms	Slept on the beach	Mehta and Shenoi (2004)
4	52	F	Housewife	Anterior abdominal wall	Gardening as a hobby	Padmavathy and Rao (2005)
5	50	F	Farm worker	Anterior abdominal wall	Spent long hours in fields	Malhotra et al. (2006)
6	38	M	Fisherman	Both legs and left hand	–	Sengupta et al. (2007)
7	35	M	–	Penis	–	Rao et al. (2007)
8	60	F	–	Dorsum of foot	Walked barefoot in her garden	Rao and Prabhu (2007)
9	12	M	–	Left foot	Played barefoot on the beach	Gutte and Khopkar (2011)
10	6	M	–	Penis	Habit of playing naked on soil	Mohanty et al. (2012)
11	50	F	Agriculturist	Wrist, fingers, its knuckle,	Handled compost	Upendra et al. (2013)
12	28	F	Housewife	Arm, back, lower abdomen and thigh	Worm-like structure peeping through lesion[a]	Mukherjee et al. (2012)

M male, *F* female

[a] Case of cutaneous gnathostomiasis

(Padmavathy and Rao 2005; Malhotra et al. 2006; Rao and Prabhu 2007; Mohanty et al. 2012). The larvae migrate about 2–5 cm per day (Karthikeyan and Thappa 2002). Lesions are most common on the feet, lower legs and buttocks (Shinkar et al. 2005), but also occur on the arms, hands, and face (Goldsmid et al. 1998). Unusual sites include abdomen (Padmavathy and Rao 2005; Malhotra et al. 2006) and penis (Kartikeyan et al. 2003) (Table 1). Occasionally *A. caninum* larvae may migrate to the human intestine, causing eosinophilic enteritis (Prociv and Croese 1990; Walker et al. 1995; CDC 2013).

Clinical symptoms in dogs

Pale membranes, anemia, weight loss, bloody stool, weakness, poor growth in puppies and stunted growth in young animals, are the common symptoms observed in ancylostomosis (Soulsby 1982; Sherding and Johnson 1994).

Diagnosis

Diagnosis is mainly based on clinical presentation along the relevant history of occupational exposure or recent travel to endemic regions. Biopsy is of no value as the larvae advance ahead of the clinical tract. To detect larva and confirm the diagnosis, epiluminescence microscopy is an effective noninvasive method (Eisher et al. 1997). Contact dermatitis, migratory myiasis and cercarial dermatitis should be on differential list (Rao et al. 2007). In dogs, coprological examination is performed for diagnosis but molecular studies are needed for species identification (Traub et al. 2003).

Treatment

CLM usually heals spontaneously within weeks or months (Caumes 2000) but the larvae may migrate for as long as 1 year (Chaudhry and Longworth 1989). If patient does not undergo treatment, complications like impetigo and local or general allergic reactions can occur (Caumes 2000). Such complications and long duration of the disease, make treatment mandatory. The treatment of choice is ivermectin (a single dose of 200 μg kg^{-1} body weight) (Caumes et al. 1993). Albendazole (400 mg a day per os for 3 days) is also effective. Freezing the leading edge of the skin track rarely works (Caumes 2000). Topical application of a 10–15 % thiabendazole is also effective (Davis and Israel 1968). Treatment in dogs include dichlorvos, pyrantel pamoate, febantel, fenbendazole and mebendazole (Lefkaditis 2001).

Visceral larva migrans (VLM)

History

Wilder (1950) was the first to describe infection in a child but identified a nematode larva of unknown species within a retinal granuloma. Beaver and colleagues, 1952 described the clinical features and *Toxocara* sp. as the cause of VLM (Beaver et al. 1952).

Etiology

VLM (Synonyms: Toxocarosis, Larval Granulomatosis) occurs due to larvae of *T. canis* and *T. cati* (Mok 1968; Zinkham 1978). Larvae of *Ascaris suum*, swine roundworm could occasionally cause infection in man (Nakamura-Uchiyama et al. 2006; Nawa et al. 1996).

Epidemiology

VLM is worldwide in distribution with high prevalence in sub tropical countries (Nawa et al. 1996; Akdemir 2010; Elshazly et al. 2011). In developed world, *Toxocara* ranks second only to pinworm infection in humans (Schantz 1989). Despite the high incidence of toxocarosis in dogs in India, first human case of VLM was recorded in 1993 (Sarda et al. 1993).Young adults and children are supposed to be at greater risk of contracting the disease (Schantz et al. 1980). Infected dogs contaminate the soil with *Toxocara* sp. eggs and ingestion of these eggs is major route of infection. Multiple conducive factors include pica or geophagia, poor hygiene, eating raw vegetables, contact with puppies and exposure to public places and parks with contaminated soil (Kantha et al. 1989; Kaplan et al. 2001; Malla et al. 2002; Dar et al. 2008). Ingestion of raw organs and meat from paratenic hosts (pigs, lamb, rabbits, chicken) also lead to the disease (Nagakura et al. 1989; English 2006). Several studies on the prevalence of *Toxocara* sp. eggs in soil have been conducted in India. Prevalence rates of *Toxocara* sp. eggs in soil samples ranging from 2.21 to 19.71 % have been reported from different parts of the country (Singh et al. 1997; Grover et al. 2000; Das et al. 2010; Thomas and Jeyathilakan 2012). Kumar and Hafeez (1998) reported that 46 % of public parks and 32 % of school grounds in Andhra Pradesh (South India) were contaminated with *Toxocara* eggs. Recently, Sudhakar et al. (2013) reported that 12.84 % of soil samples were contaminated with the *Toxocara* spp. eggs in Uttar Pradesh (North India) and public parks were more contaminated than the other sites. Access of dogs to such places poses serious public health risk in the country. Lack of knowledge could further increase occurrence of disease. In a survey in Pondicherry, 21.66 % dog owners had no idea regarding transmission of *T. canis* to humans (Das et al. 2007).

Status in India

Occurrence in humans

Routine epidemiological surveys involve serological methods for the diagnosis of the disease. Seroprevalence studies indicated the prevalence rates of 32.86 and 6.4 % of human toxocarosis from Jammu & Kashmir and Haryana, states of northern India, respectively (Malla et al. 2002; Dar et al. 2008). Sporadic cases of VLM have also been reported from many other states (Table 2).

Occurrence in dogs

High prevalences range of 55.8 and 82 % were observed in Miraj and Calcutta, respectively (Mapplestone and Bhaduri 1940; Joshi and Sabne 1977). In contrast, low prevalence was seen in Madhya Pradesh (2.7 %), Himachal Pradesh (5.93 %), and Chandigarh (9.6 %) (Sahasrabudhe et al. 1969; Sreenivas and Mahajan 1991; Agnihotri et al. 2008). Prevalence of *T. canis* was 11 % in dogs in tea estates in Assam (Traub et al. 2002). Sahu et al. (2012) found 24.3 % incidence of *Toxocara* ova in dogs in Uttar Pradesh. Incidence was 38 and 45 % among adult dogs and puppies in Nagpur (Khante et al. 2009). Most of the studies reported high prevalence in puppies (Sreenivas and Mahajan 1991; Khante et al. 2009; Das et al. 2009) and stray dogs as compared to adult dogs and pets (Sahu et al. 2012; Das et al. 2009).

Health implications in humans

Clinical manifestations mainly depend upon the site of larval migration. Most important sites are liver, lungs, heart and CNS. Infection remains asymptomatic most of the times (Bass et al. 1987). Fever, hepatomegaly, liver necrosis, spleenomegaly, eosinophilia (Huntley et al.1965; Schantz and Glickman 1978; Jain et al. 1994; Thakkar et al. 2012) and myocarditis (Dao and Virmani 1986; Kim et al. 2012) are the important clinical manifestations. Pulmonary involvement can result in cough, wheeze, dyspnea and pneumonia, or asthma (Cianferoni et al. 2006). Signs such as seizures, neuropsychiatric symptoms, or encephalopathy could be seen during CNS involvement (Jagannath et al. 2009).

Clinical symptoms in dogs

Toxocarosis causes serious disease in pups whereas in adult dogs usually remains asymptomatic. The parasite causes serious blood loss, acute gastrointestinal hemorrhages, anemia, poor growth, loss of condition and sometimes an enlarged abdomen (Kagira and Kanyari 2000). Death may occur in severe cases.

Diagnosis

For diagnosis of VLM in humans, serological tests like Enzyme-linked immunosorbent assay (ELISA) can be used (Schantz 1989; Bhatia and Sarin 1994; Thakkar et al. 2012). Imaging techniques such as ultra sonography, CT scan and MRI could also be used to aid in diagnosis (Jain et al. 1994; Jagannath et al. 2009). Liver biopsy can also be

Table 2 Detail of cases of VLM in humans in India

S. No	Age (years)	Sex	Symptoms observed	Diagnostic aid	Reference
1	35	F	Intermittent high grade fever and chills for duration of 1.5 years	CT & MRI	Laroia et al. (2012)
2	58	M	Low grade fever off and on for past three months		
3	51	M	Liver abscess		
4	45	M	Fever and pain in the right upper quadrant	Serology	Bhatia and Sarin (1994)
5	33	F	PUO since 3–5 month, abdominal pain and hepatomegaly	Histopathology, Sonograms, MRI scan	Jain et al. (1994)
6	19	F			
7	40	M			
8	13	F	Recurring episodes of left & right focal motor seizures, vomiting and diffuse headache, progressive left hemiparesis and altered sensorium[a]	Histopathology, MRI & CT scan,	Jagannath et al. (2009)
9	45	F	Recurrent colicky pain in the right hypochondrium	Histopathology	Sarda et al. (1993)
10	38	M	Multiple intracranial and intramedullary abscesses		Moiyadi et al. (2007)
11	2-1/2		Fever, anorexia and hepatosplenomegaly	Histopathology, CT scan, serology	Thakkar et al. (2012)

M male, *F* female

[a] Case of cerebral larva migrans

performed in diagnosing VLM. For diagnosis in dogs, faecal examination is done to observe the parasite's ova.

Treatment

A variety of anthelmintic drugs are used for the treatment of toxocarosis (Despommier 2003). Administration of corticosteroids can be used in order to suppress the intense allergic manifestations of the infection.

Ocular larva migrans (OLM)

Etiology

OLM also known as Toxocaral Retinitis is mainly caused by larvae of *T. canis* and *T. cati* (Mirdha and Khokar 2002; Fomda et al. 2007). Occasionally, *Baylisascaris procyonis*, raccoon roundworm can lead to OLM in humans (Brasil et al. 2006). VLM and OLM are the two main clinical presentations of toxocariasis.

Epidemiology

Occurrence in humans

Few studies have been carried out on OLM in India. Moreover, disease has been under reported due to lack of diagnostic aids in most parts of the country. In north India, a serological study on patients with ocular manifestations and suspected for toxocarosis indicated presence of anti-*Toxocara* antibodies in 11 subjects of less than 15 years old (17 %) and three subjects of more than 15 years old (4 %) out of total 68 patients (Mirdha and Khokar 2002). Fomda et al. (2007) reported a case of OLM in 12 year old girl from Kashmir.

Health implications in humans

Ocular toxocarosis is frequently observed in older children and young adults. OLM is usually unilateral (Yokoi et al. 2003; Stewart et al. 2005) and there is decrease in visual acuity, strabismus, or leukocoria (Shields 1984). Bilateral involvement is extremely rare (Benitez del Castillo et al. 1995). Most common presenting manifestations are impairment of visual acuity and leukocoria.

Diagnosis

The disease could be diagnosed from clinical signs. ELISA on serum samples can be performed to diagnose the disease (Shields 1984). Some authors have also demonstrated ELISA on intraocular fluids as a useful diagnostic aid (Biglan et al. 1979; Gillespie et al. 1993).

Treatment

Antihelmintic drugs and corticosteroids have been used to treat OLM (Dinning et al. 1988; Maguire et al. 1990)

Retinal detachment is the most common indication for surgical intervention (Hagler et al. 1981) Vitrectomy can be performed to treat such condition (Belmont et al. 1982; Small et al. 1989).

Neural larva migrans

NLM occurs due to migrating larvae of the raccoon roundworm, *B. procyonis,* which may lead to severe neurologic disease. It is mostly prevalent in the countries where raccoons are present like northern and midwestern United States (Gavin et al. 2002). It causes eosinophilic meningoencephalitis in humans, primarily in children with significant environmental contact (Murray and Kazacos 2004; Gavin et al. 2005). Raccoons are not native to India thus no case of NLM has been reported from India.

Control

Control of stray dog population is of utmost importance to combat larva migrans and other potential zoonotic diseases such as rabies. Measures that prevent infected dog faeces from contaminating the environment are of paramount importance. City municipals in collaboration with NGOs must take steps like controlling stray dog population and fencing the public places, parks and play grounds to check the entry of stray dogs. Deworming of dogs against these zoonotic helminths is also of cardinal importance. Owners should dispose of dog faeces properly. Systematic surveillance should be made by health agencies in order to obtain the exact disease burden which would be the basis of future control programs. Physicians should also include larva migrans in the differential list of similar manifestations as they mimic some of the other medical problems in endemic areas. Playing or walking barefoot on the beach or gardens should be avoided. Good hygienic measures like washing hands after playing on beach or with dogs or gardening should be cultured to general public. Discourage geophagia in kids and encourage them to adopt good hygienic practices. Awareness campaign should be carried in order to educate the dog owners as well as common people. Travelers should be advised on how to avoid exposure to these parasites.

Conclusion

Recognition of Larva migrans as an important public health problem is most important step to combat this neglected disease in developing countries like India. Given the high prevalence of the disease in dogs, improved sanitary and hygienic practices must be adopted throughout the country. What is required in terms of future control programs is the development of easy to perform diagnostics and their availability in endemic areas. Dogs may act as sentinels of such zoonotic parasites and incidence in them permits indirect assessment of human risk. Therefore, it alarms for surveillance of such important but neglected parasitic zoonosis in dogs and humans simultaneously in order to achieve the true picture of the problem, collaborative efforts by veterinary and medical professionals will further increase the success of control programs.

References

Agnihotri RK, Sharma D, Sharma Y (2008) Incidence of gastrointestinal helminths in dogs of Himachal Pradesh. J Vet Parasitol 22:89–90

Akdemir C (2010) Visceral larva migrans among children in Kutahya (Turkey) and an evaluation of playgrounds for *T. canis* eggs. Turk J Pediatr 52:158–162

Bass JL, Mehta KA, Glickman LT (1987) Asymptomatic toxocariasis in children. Clin Pediatr (Phila) 26:441–446

Beaver PC (1956) Larva migrans: a review. Exp Parasitol 5:587–621

Beaver PC, Snyder CH, Carrera GM et al (1952) Chronic eosinophilia due to visceral larva migrans; report of three cases. Pediatrics 9:7–19

Belmont JB, Irvine A, Benson W, Connor GR (1982) Vitrectomy in ocular toxocariasis. Arch Ophthalmol 100:1912–1915

Benitez del Castillo JM, Herreros G, Guillen JL, Fenoy S, Banares A, Garcia J (1995) Bilateral ocular toxocariasis demonstrated by aqueous humor enzyme-linked immunosorbent assay. Am J Ophthalmol 119:514–516

Bhatia V, Sarin SK (1994) Hepatic visceral larva migrans: evolution of the lesion, diagnosis, and role of high-dose albendazole therapy. Am J Gastroenterol 89:624–627

Biglan AW, Glickman LT, Lobes LA Jr (1979) Serum and vitreous Toxo-cara antibody in nematode endophthalmitis. Am J Ophthalmol 88:898–901

Bouchaud O, Houze S, Schiemann R, Durand R, Ralaimazava P, Ruggeri C, Coulaud JP (2001) Cutaneous larva migrans in travelers: a prospective study, with assessment of therapy with ivermectin. Clin Infect Dis 31:493–498

Brasil OFM, Lewis H, Lowder CY (2006) Migration of *Baylisascaris procyonis* into the vitreous. Br J Ophthalmol. doi: 10.1136/bjo.2006.095323 PMCID: PMC1857416

Bryceson ADM, Hay RJ (1992) Parasitic worms and protozoa. In: Champion RH, Burton JL, Ebling FJ (eds) Textbook of dermatology. Blackwell, Oxford, pp 1217–1264

Caumes E (2000) Treatment of cutaneous larva migrans. Clin Infect Dis 30:811–814

Caumes E, Carrière J, Datry A, Danis M, Gentilini M (1993) A randomized trial of ivermectin versus albendazole for the treatment of cutaneous larva migrans. Am J Trop Med Hyg 49:641–644

Caumes E, Carriere J, Guermonprez G, Bricaire F, Danis M, Gentilini M (1995) Dermatoses associated with travel to tropical countries: a prospective study of the diagnosis and management of 269 patients presenting to a tropical disease. Clin Infect Dis 20:542–548

CDC (2013) Parasites-zoonotic hookworms: Biology. http://www.cdc.gov/parasites/hookworm/biology.html Accessed 10 May 2013

Chaudhry AZ, Longworth DL (1989) Cutaneous manifestations of intestinal helminthic infections. Dermatol Clin 7:275–290

Cianferoni A, Schneider L, Schantz PM, Brown D, Fox LAM (2006) Visceral larva migrans associated with earthworm ingestion: clinical evolution in an adolescent patient. Pediatric 117:336–339

Crocker HR (1893) Diseases of the Skin, 2nd edn. Blakiston, Philadelphia

Dao AH, Virmani R (1986) Visceral larva migrans involving the myocardium: report of two cases and review of literature. Pediatr Pathol 6:449–456

Dar ZA, Tanveer S, Yattoo GN, Sofi BA, Wani SA, Dar PA, Fomda BA (2008) Seroprevalence of Toxocariasis in children in Kashmir, J&K State, India. Iranian J Parasitol 3:45–50

Das SS, Kumar D, Sreekrishnan R (2007) Assessment of awareness of dog owners about public health importance of *Toxocara canis* infection in Pondicherry. J Vet Parasitol 21:69–70

Das SS, Kumar D, Sreekrishnan R, Ganesan R (2009) Gastrointestinal parasitic infections in dogs in Puducherry. J Vet Parasitol 23:77–79

Das SS, Kumar D, Sreekrishnan R, Ganesan R (2010) Soil contamination of public places, play grounds and residential areas with ova of Toxocara. Indian J Vet Res 18:13–16

Davis CM, Israel RM (1968) Treatment of creeping eruption with topical thiabendazole. Arch Dermatol 97:325–326

Despommier D (2003) Toxocariasis: clinical Aspects, Epidemiology, Medical Ecology, and Molecular Aspects. Clin Microb Rev 16:265–272

Dinning WJ, Gillespie SH, Cooling RI, Maizels RM (1988) Toxocariasis: a practical approach to management of ocular disease. Eye 2:580–582

Eisher E, Themes M, Worret WC (1997) Cutaneous larva migrans detected by epiluminescent microscopy. Acta Derm Venereol 77:487–488

Elshazly AM, Attia G, El-Ghareeb AS, Belal US (2011) Clinical varieties of *Toxocariasis canis* in Children's Hospital, Mansoura University: is it an underestimated problem. J Egypt Soc Parasitol 41:263–274

English BK (2006) *Toxocara* Infection. In: Mc Millain JA (ed) Oskis paediatric principles and practice, 4th edn. Lippincott, Philadelphia, pp 1370–1372

Fomda BA, Ahmad Z, Khan NN, Tanveer S, Wani SA (2007) Ocular toxocariasis in a child: a case report from Kashmir, north India. Indian J Med Microbiol 25:411–412

Gavin PJ, Kazacos KR, Tan TQ, Brinkman WB, Byrd SE, Davis AT, Mets MB, Shulman ST (2002) Neural larva migrans caused by the raccoon roundworm *Baylisascaris procyonis*. Pediatr Infect Dis J 21:971–975

Gavin PJ, Kazacos KR, Shulman ST (2005) Baylisascariasis. Clin Microbiol Rev 18:703–718

Gillespie SH, Dinning WJ, Voller A, Crowcroft NS (1993) The spectrum of ocular toxocariasis. Eye 7:415–418

Goldsmid J, Kibel MA, Mills AE (1998) Cutaneous larva migrans. In: Campbell AGM, McIntosh N (eds) Textbook of paediatrics. Churchill Livingstone, Oxford, pp 1490–1491

Grover R, Bhatti G, Aggarwal A, Malla N (2000) Isolation of *Toxocara* eggs in and around Chandigarh, India. J Parasitic Dis 24:57–59

Gutte R, Khopkar U (2011) Cutaneous larva migrans (creeping eruption). Indian Dermatol Online J 2:48

Hagler WS, Pollard ZF, Jarrett WH, Donnelly EH (1981) Results of surgery for ocular *Toxocara canis*. Ophthalmology 88:1081–1086

Huntley CC, Costas MC, Lyerly A (1965) Visceral larva migrans syndrome: clinical characteristics and immunologic studies in 51 patients. Pediatrics 36:523–536

Jagannath PM, Venkataramana NK, Rao SA, Naik AL, Shivakumar SK, Saktepar A, Gopalakrishnan R, Shankar SK (2009) Recurrent cerebral larva migrans: a case report and review of literature. J Pediatr Neurosci 4:36–40

Jain R, Sawhney S, Bhargava DK, Panda SK, Berry M (1994) Hepatic granulomas due to visceral larva migrans in adults: appearance on US and MRI. Abdom Imaging 19:253–256

Joshi BN, Sabne SS (1977) Incidence of *Toxocara* canis infection in stray dogs in Miraj area. Indian J Pathol Microbiol 20:239–242

Kagira JM, Kanyari PWN (2000) The role of parasitic diseases as causes of mortality in dogs: a retrospective study of 351 cases (1984–1998) Israel J. Vet Med 56:9–11

Kantha R, Vivekanandan S, Natarajan S, Gopal L, Badrinath SS (1989) ELISA and vitrectomy in the diagnosis and management of ocular toxocariasis. Nethralaya Insight 6:16–19

Kaplan KJ, Goodman ZD, Ishak KG (2001) Eosinophilic granuloma of the liver: a characteristic lesion with relationship to visceral larva migrans. Am J Surg Pathol 25:1316–1321

Karthikeyan K, Thappa D (2002) Cutaneous larva migrans. Indian J Dermatol Venereol Leprol 68:252–258

Kartikeyan K, Thappa DM, Jeevankumar B (2003) Cutaneous larva migrans of the penis. Sex Transm Infect 79:500

Kazacos KR (2001) *Baylisascaris procyonis* and related species. In: Samuel WM, Pybus MJ, Kocan AA (eds) Parasitic diseases of wild mammals, 2nd edn. Iowa State University, Ames, pp 301–341

Khante GS, Khan LA, Bodkhe AM, Suryawanshi PR, Majed MA, Suradkar US, Gaikwad SS (2009) Epidemiological survey of Gastro-intestinal parasites of Non-descript dogs in Nagpur city. Vet world 2(1):22–23

Kim JH, Chung WB, Chang KY, Ko SY, Park MH, Sa YK, Choi YS, Park CS, Lee MY (2012) Eosinophilic myocarditis associated with visceral larva migrans caused by *Toxocara Canis* infection. J Cardiovasc Ultrasound 20:150–153

Kumar D, Hafeez M (1998) A study on the prevalence of *Toxocara* spp eggs at public places in Andhra Pradesh. J Commun Dis 30:197–198

Kurokawa M, Ogata K, Sagawa S, Miyaoka Y, Noda S, Nawa Y (1998) Cutaneous and visceral larva migrans due to Gnathostomadoloresi infection via an unusual route. Arch Dermatol 134:638–639

Laroia ST, Rastogi A, Sarin S (2012) Case series of visceral larva migrans in the liver: cT and MRI findings. Int J Case Rep Images 3:7–12

Lefkaditis M (2001) Ancylostomiasis in dogs. Scientia Parasitologica 1:15–22

Maguire AM, Zarbin MA, Connor TB, Justin J (1990) Ocular penetration of thiabendazole. Arch Ophthalmol 108:1675

Malaki A (1966) A survey of gastro-intestinal parasites of dogs in Bangalore with notes on some interesting observations. Indian Vet J 43:409–412

Malhotra SK, Raj TR, Pal M, Goyal V, Sethi S (2006) Cutaneous larva migrans in an unusual site. Dermatol Online J 12:11

Malla N, Aggarwal AK, Mahajan RC (2002) A serological study of human toxocariasis in north India. The Nat Med J Ind 15:145–147

Manson-Bahr PEC, Bell (1987) In: Tindall, Saimot AG (eds) Mason's tropical diseases, 19th edn. Crem, London

Mapplestone FA, Bhaduri NV (1940) The helminth parasites of dogs in Calcutta and their bearing on human parasitology. Indian J Med Res 28:595

Meffert JI (1977) Parasitic infestations. In: Fitzpatrick AJ (ed) Dermatology secrets, 1st edn. Jaypee Brothers, New Delhi, p 217

Mehta V, Shenoi SD (2004) Extensive larva migrans. Ind J Dermatol Venereol Leprol 70:373–374
Mirdha BR, Khokar SK (2002) Ocular toxocariasis in a North Indian population. J Trop Pediatr 6:328–330
Mohanty I, Patnaik S, Mohanty P (2012) An unusual presentation of cutaneous larva migrans in a male child. Ind J Med Micro 30:486–487
Moiyadi A, Mahadevan A, Anandh B, Shivashankar RS, Chickabasavaiah YT, Shankar SK (2007) Visceral larva migrans presenting as multiple intracranial and intraspinal abscesses. Neuropathology 27:371–374
Mok CH (1968) Visceral larva migrans: a discussion based on review of the literature. Clin Pediatr 7:565–573
Mukherjee A, Ahmed NH, Samantaray JC, Mirdha BR (2012) A rare case of cutaneous larva migrans due to *Gnathostoma* sp. Indian J Med Microbiol 30:356–358
Murray WJ, Kazacos KR (2004) Raccoon roundworm encephalitis. Clin Infect Dis 39:1484–1492
Nagakura K, Tachibana H, Kaneda Y, Kato Y (1989) Toxocariasis possibly caused by ingesting raw chicken. J Infect Dis 160:735–736
Nakamura-Uchiyama F, Tokunaga Y, Suzuki A, Akao N, Hiromatsu K, Hitomi S, Nawa Y (2006) A case of *Ascaris suum* visceral larva migrans diagnosed by using *A. suum* larval excretory-secretory (ES) antigen. Scand J Infect Dis 38:221–224
Nash T (1990) Visceral larva migrans and other unusual helminth infections. In: Mandell G, Douglas R, Bennett J (eds) Principle and practice of infectious diseases, 3rd edn. Churchill Livingstone, New York, p 2340
Nawa Y, Maruyama H, Noda S (1996) Viseceral larva migrans due to *Ascaris suum* in Kyusyu. Infect Agents Surveillance Rep 17:191–192 (in Japanese)
Neafie RC, Meyers WM (2000) Cutaneous larva migrans. In: Strickland GT (ed) Hunters tropical medicine and emerging infectious diseases, 8th edn. Sounders, Philadelphia, pp 797–799
Padmavathy L, Rao LL (2005) Cutaneous larva migrans—a case report. Ind J Med Microbiol 23:135–136
Prociv P, Croese J (1990) Human eosinophilic enteritis caused by dog hookworm *Ancylostoma caninum*. Lancet 335:1299–1302
Rao R, Prabhu S (2007) A serpiginous eruption on the foot of a female. J Pak Assoc Dermatol 17:66–68
Rao R, Prabhu S, Sripathi H (2007) Cutaneous larva migrans of the genitalia. Ind J Dermatol Venereol Leprol 73:270–271
Sahai BN (1969) A survey of the helminth parasites of stray dogs in and around Bareilly, Uttar Pradesh. Indian Vet J 46:734
Sahasrabudhe VK, Dubey JP, Srivastav HO (1969) Helminth parasites of dogs in Madhya Pradesh and their public health significance. Ind J Med Res 57:56–59
Sahu S, Samanta S, Sudhakar NR, Raina OK, Gupta SC, Maurya PS, Pawde AM, Kumar A (2012) Prevalence of canine toxocariasis in Bareilly, Uttar Pradesh, India. J Parasit Dis, 1–5. doi: 10.1007/s12639-012-0207-z
Sarda AK, Kannan R, Sharma DK, Mahajan V, Goel A, Uma K (1993) Visceral larva migrans. J Postgrad Med 39:155–157
Schantz PM (1989) *Toxocara* larva migrans now. Am J Trop Med Hyg 41:21–34
Schantz PM, Glickman LT (1978) *Toxocara*l visceral larva migrans. N Engl J Med 298:436–439
Schantz PM, Weis PE, Pollard ZF, White MC (1980) Risk factors for *Toxocara*l ocular larva migrans: a case control study. Am J Public Health 70:1269–1272
Sengupta S, Das JK, Gangopadhyay A (2007) Creeping eruption: a spectacular presentation. Indian J Dermatol 52:165–166
Sherding RG, Johnson SE (1994) Diseases of the intestine. In: Birchard SJ, Sherding RG (eds) Saunders manual of small animal practice. WB Saunders Co, Philadelphia, pp 696–698
Shields JA (1984) Ocular toxocariasis: a review. Surv Ophthalmol 28:361–381
Shinkar RM, Stocks R, Thomas E (2005) Cutaneous larva migrans, creeping eruption, sand worm. Arch Dis Child. doi: 10.1136/adc.2005.073197
Singh H, Bali HS, Kaur A (1997) Prevalence of *Toxocara* spp. eggs in the soil of public and private places in Ludhiana and Kellon area of Punjab, India. Epidemiol Sante Anim, pp 31–32
Singh BB, Sharma R, Sharma JK, Juyal PD (2010) Parasitic zoonoses in India—an overview. Rev Sci Tech Off Int Epiz 29:629–637
Singh BB, Sharma R, Gill JPS, Aulakh RS, Banga HS (2011) Climate change, Zoonoses and India. Rev sci tech Off int Epiz 30:779–788
Singh BB, Sharma JK, Ghatak S, Sharma R, Bal MS, Tuli A, Gill JPS (2012) Molecular epidemiology of Echinococcosis from food producing animals in north India. Vet Parasitol 186:503–506
Singh BB, Singh G, Sharma R, Sharma JK, Aulakh RS, Gill JPS (2013) Human hydatidosis: an underdiscussed occupational zoonosis in India. Helminthologia 50(2):87–90
Small KW, McCuen BW, De Juan E, Machemer R (1989) Surgical management of retinal retraction caused by toxocariasis. Am J Ophthalmol 108:10–14
Soulsby EJL (1982) Helminths, arthropods and protozoa of domesticated Animals. Lea & Febiger, Philadelphia
Sreenivas K, Mahajan RC (1991) Prevalence of *Toxocara Canis*. In pet dog population in Chandigarh. Indian J med microbiol 9:29–31
Stewart JM, Cubillan LD, Cunningham ET Jr (2005) Prevalence, clinical features, and causes of vision loss among patients with ocular toxocariasis. Retina 25:1005–1013
Sudhakar NR, Samanta S, Sahu S, Raina OK, Gupta SC, Madhu DN, Kumar A (2013) Prevalence of *Toxocara* species eggs in soil samples of public health importance in and around Bareilly, Uttar Pradesh, India. Vet World 6:87–90
Sugathan P (2002) Massive infestation of cutanea larva migrans. Dermatol Online J 8:21
Tamminga N, Bierman WFW, de Vries PJ (2009) Cutaneous larva migrans acquired in Brittany, France. Emerg Infect Dis. http://www.cdc.gov/EID/content/15/11/1856.htm. Accessed on Feb 2013
Tao Y, Zhao LN, Fan MJ, Wu H, Chen QK (2012) Visceral larva migrans associated with earthworm and gecko ingestion: a case report. J Med Case Reports. doi:10.1186/1752-1947-6-210
Thakkar PA, Dahat A, Shukla O, Javadekar (2012) An interesting case of visceral larva migrans (VLM). Int J Med Sci Public Health 1:101–104
Thomas D, Jeyathilakan N (2012) Detection of *Toxocara* eggs in contaminated soil from various public places of Chennai city and detailed correlation with literature. J Parasitic Dis. doi: 10.1007/s12639-012-0217-x
Traub RJ, Robertson ID, Irwin P, Mencke N, Thompson A (2002) The role of dogs in transmission of gastrointestinal parasites in a remote tea-growing community in Northeastern India. Am J Med Hyg 67:539–545
Traub RJ, Robertson ID, Irwin P, Mencke N, Monis P, Thompson RC (2003) Humans, dogs and parasitic zoonoses—unravelling the relationships in a remote endemic community in northeast India using molecular tools. Parasitol Res 90:S156–S157
Traub RJ, Robertson ID, Irwin P, Mencke N, Thompson RC (2004) Application of a species-specific PCR-RFLP to identify *Ancylostoma* eggs directly from canine faeces. Vet Parasitol 123:245–255
Traub RJ, Hobbs RP, Adams PJ, Behnke JM, Harris PD, Thompson RC (2007) A case of mistaken identity—reappraisal of the species of canid and felid hookworms (*Ancylostoma*) present in Australia and India. Parasitol 134:113–119

Upendra Y, Mahajan VK, Mehta KS, Chauhan PS, Chander B (2013) Cutaneous larva migrans. Indian J Dermatol Venereol Leprol 79:418–419. doi:10.4103/0378-6323.110770

Vega-Lopez F, Hay RJ (2004) Parasitic worm and protozoa. In: Burns T, Breathnach S, Cox N, Griffiths C (eds) Rooks textbook of dermatology, 7th edn. Blackwell, Oxford, pp 35.17–35.18

Walker NI, Croese J, Clouston AD, Parry M, Loukas A, Prociv P (1995) Eosinophilic enteritis in northeastern Australia. Pathology, association with *Ancylostoma caninum* and implications. Am J Surg Pathol 19:328–337

Wilder HC (1950) Nematode endophthalmitis. Trans Am Acad Ophthalmol Otolaryngol 55:99–104

Yokoi K, Goto H, Sakai J, Usui M (2003) Clinical features of ocular toxocariasis in Japan. Ocul Immunol Inflamm 11:269–275

Zinkham WH (1978) Visceral larva migrans: a review and reassessment indicating two forms of clinical expression: visceral and ocular. Am J Dis Child 132:627–633